NASA Langley's
Fail-Safe High-Temperature Composite Structure

A combination structural support and thermal protection system that maintains structural and thermal protection integrity even when damaged

The NASA Langley-developed system provides both structural support and thermal protection attributes in a "fail safe" manner. This innovation incorporates the use of a PCP composite structure that when overheated or exposed to fire or plasma will convert to a ceramic matrix composite (CMC), retaining structural integrity and still functioning effectively. When damage causes the thermal protection system (TPS) to fail, the underlying PCP structure converts to a CMC material that has high-temperature structural properties, will not catch fire or melt, and continues to perform its structural function.

The system can be used in a variety of vehicles and static structures, such as incorporation into a building to keep it structurally sound during a fire. Used in a re-entry heat shield, it costs less to produce than current heat shield systems. The technology also has applicability to engines in general aviation aircraft, turbines, automobiles, or other ground vehicles.

Benefits

- Inherently fail-safe structure converts to CMC with structural integrity intact when overheated due to TPS damage
- Cure-in-place heat shield is lower cost to produce than current heat shield systems
- Offers a lower-cost method of producing CMC materials
- Carbon fiber length and amount can be tailored for a specific application
- Can optimize the ratio of polymer to ceramic particulates to obtain acceptable densities and strengths

partnership opportunity

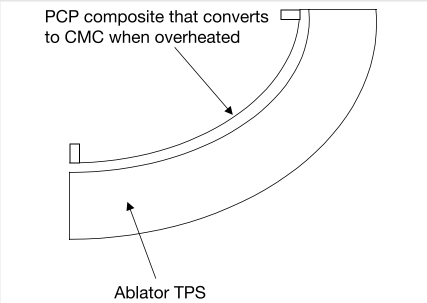

Figure 1: PCP Composite TPS Carrier Structure that converts to CMC when overheated

Applications

The technology offers wide-ranging market applications, including:

- STPS carrier structure for a heat-shield structure
- Rocket engine blast shield
- Low-cost convert-during-use heat shield for an atmospheric entry vehicle
- TPS panels
- Integral TPS/structure that converts-in-place forming a functionally graded wall structure
- Low-cost CMC material production
- Engine firewalls in general aviation aircraft, turbine engines, automobiles, or other ground vehicles
- Fail-safe TPS carrier structure for atmospheric entry vehicles supporting exploration and science missions or commercial space travel
- Missile components that cure during flight
- Building construction to ensure structural soundness during a fire
- High-performance racing engines

For More Information

If your company is interested in licensing or joint development opportunities associated with this technology, or if you would like additional information on partnering with NASA, please contact:

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The Technology

State-of-the-art thermal protection systems typically include a support or carrier structure with thermal protection material/elements coupled to the carrier structure and exposed to an ambient, high-temperature environment. The carrier structure is generally made from a low-temperature material such as aluminum, titanium, or one of many polymer matrix composites, which function well as long as the structural integrity of the thermal protection material is maintained. If they fail or are damaged (due to an impact, chemical breakdown, etc.), the carrier structure can overheat and fail as the temperature increases in the region of the failure.

The technology incorporates a polymer matrix composite TPS carrier structure fabricated with a carbon-fiber-reinforced preceramic polymer matrix containing ceramic particulates. During fabrication, the carbon fibers are coated with an interfacial coating prior to application of the preceramic polymer. The structure is then cured using standard polymer matrix composite processing; it is inherently fail safe. If the TPS protecting the structure is damaged or lost, the carrier structure will convert to a CMC material when its temperature reaches 1000°C. The converted CMC structure will maintain structural integrity, ensuring the safe completion of the mission. Because density is lost during conversion of the preceramic polymer, the ratio of polymer to ceramic particulates can be optimized to obtain acceptable densities and strengths.

Samples have been developed and successfully tested at the Wright-Patterson LHMEL facility.

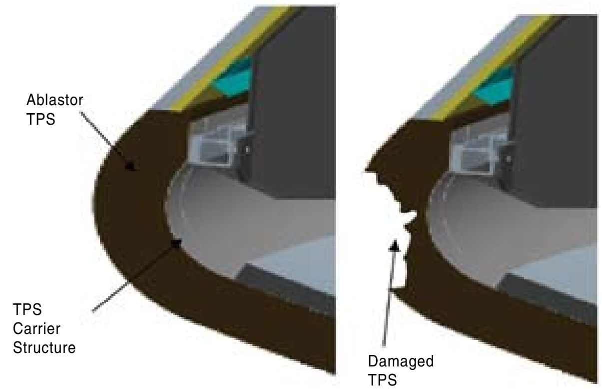

Figure 2: Typical TPS carrier structure design for an atmospheric entry vehicle

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